Mars 2020 Project

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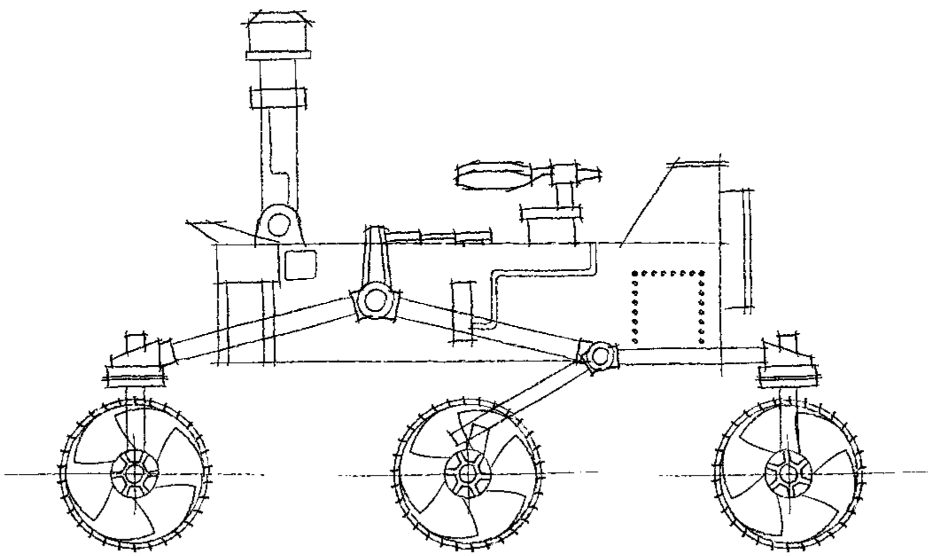
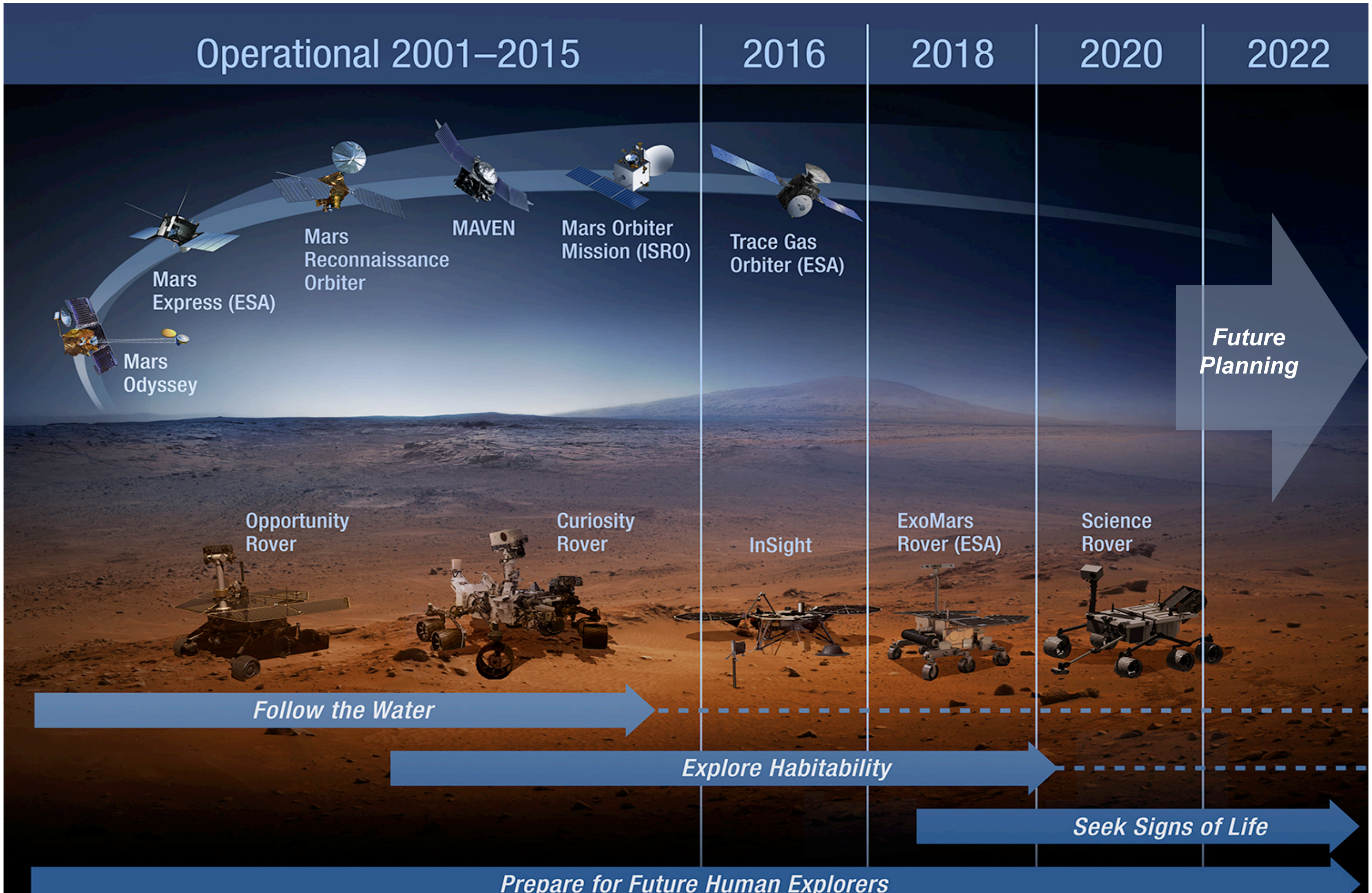


Mars 2020 Project

Mars Exploration in This Decade

Baseline Mars 2020 mission addresses the highest priority science

- Builds on Curiosity results by investigating a landing site for possible bio-signature preservation in full geologic context
- Provides HEOMD/STMD contributions to address key Strategic Knowledge Gaps
- Provides cached samples for possible return



This document has been reviewed and determined not to contain export controlled technical data.

Mars 2020 Mission Objectives

- **Conduct Rigorous *In Situ* Science**

  A. Geologic Context and History Carry out an integrated set of context, contact, and spatially-coordinated measurements to characterize the geology of the landing site

  B. In Situ Astrobiology Using the geologic context as a foundation, find and characterize ancient habitable environments, identify rocks with the highest chance of preserving signs of ancient Martian life if it were present, and within those environments, seek the signs of life

- **Enable the Future**

  C. Sample Return Assemble rigorously documented and returnable cached samples for possible future return to Earth

  D. Human Exploration Facilitate future human exploration by making significant progress towards filling major strategic knowledge gaps and…

  Technology …demonstrate technology required for future Mars exploration

- **Execute Within Current Financial Realities**
  - Utilize MSL-heritage design and a moderate instrument suite to stay within the resource constraints specified by NASA

These are a thoroughly integrated set of objectives to support Agency's Journey to Mars

Mission Overview

LAUNCH

- MSL Class/Capability LV
- Period: Jul/Aug 2020

CRUISE/APPROACH

- 7.5 month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL system (Range Trigger baselined, Terrain Relative Navigation funded thru PDR): guided entry and powered descent/Sky Crane
- 16 x 14 km landing ellipse (range trigger baselined)
- Access to landing sites ±30° latitude, ≤ -0.5 km elevation
- Curiosity-class Rover

SURFACE MISSION

- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

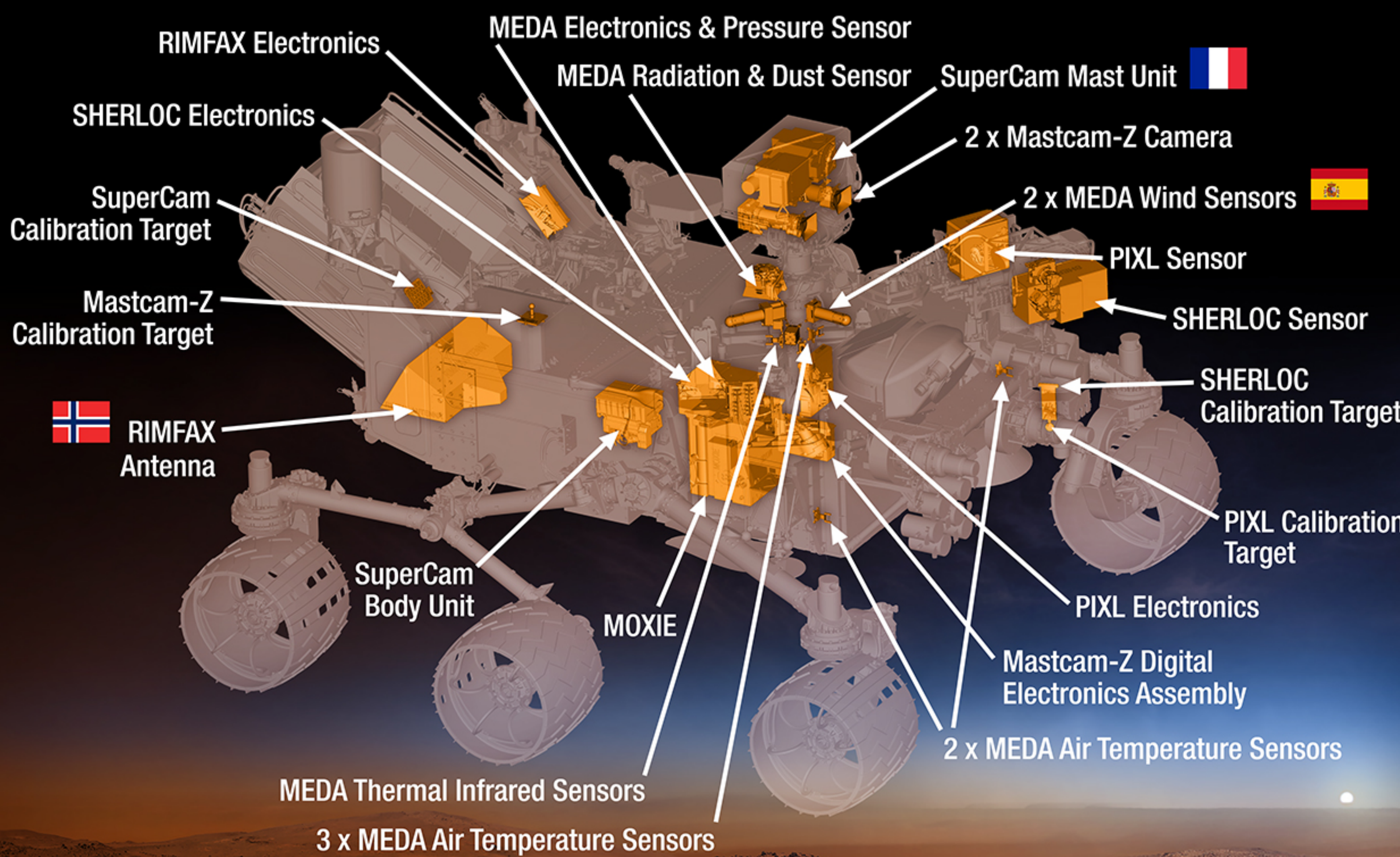
Major Accomplishments in Phase A

- Evaluated 57 proposals in response to the competitive Announcement of Opportunity (AO) for science & exploration technology investigations; announced the 7 selected investigations for the rover payload on 31 July 2014
- Formalized agreement with HEOMD/STMD for contributions of MEDLI2 and exploration technology investigations
- Conducted 1st Landing Site Workshop in August 2014; collecting new imaging and analysis for top sites
- Aggressive procurement of heritage hardware. Parts buys and procurements for items with low risk of change are proceeding at a fast pace.
- Completed Phase A trade studies and closed out decisions on augmented direct-to-Earth telecommunication, ringsail parachute, and other flight system modifications
- Sampling and caching architecture development laboratory and testbed established at JPL
- Issued Environmental Impact Statement Record of Decision on January 27, thus completing compliance with National Environmental Policy Act (NEPA)
- SRR/MDR (Life Cycle Review Step 1) completed 29 October 2014
- Completed instrument accommodation reviews on 3 March 2015
- Payload Systems Review (Life Cycle Review Step 2) completed 12 March 2015
- Approved for Phase B by Agency Program Management Council on 20 May 2015

Timeline to KDP-C

Jul 2014	-	Instrument Selection
27-29 Oct 2014	-	System Requirements Review/Mission Definition Review
Dec'14 - Mar'15	-	Instrument Accommodation Reviews
17 Feb 2015	-	Operations Productivity Update
3-4 Mar 2015	-	Planetary Protection Approach Implementation Independent Assessment Review
11-12 Mar 2015	-	Payload (+) Systems Review
25 March	-	KDP-B JPL Center Management Council completed
8 May	-	KDP-B SMD Program Management Council (DPMC) completed
20 May	-	KDP-B Agency Program Management Council (APMC) completed
Jul/Aug 2015	-	Pre-PDR Reviews (EDL, FS, SCS, Ops, Cost, etc.)
4-6 Aug 2015	-	2nd Landing Site Workshop
Sept 2015	-	Preliminary Design Review (PDR) Step 1
Dec 2015	-	PDR Step 2 (payload & related elements)
1st Qtr 2016	-	KDP-C

Mars 2020 Instrument Payload Accommodated on Rover

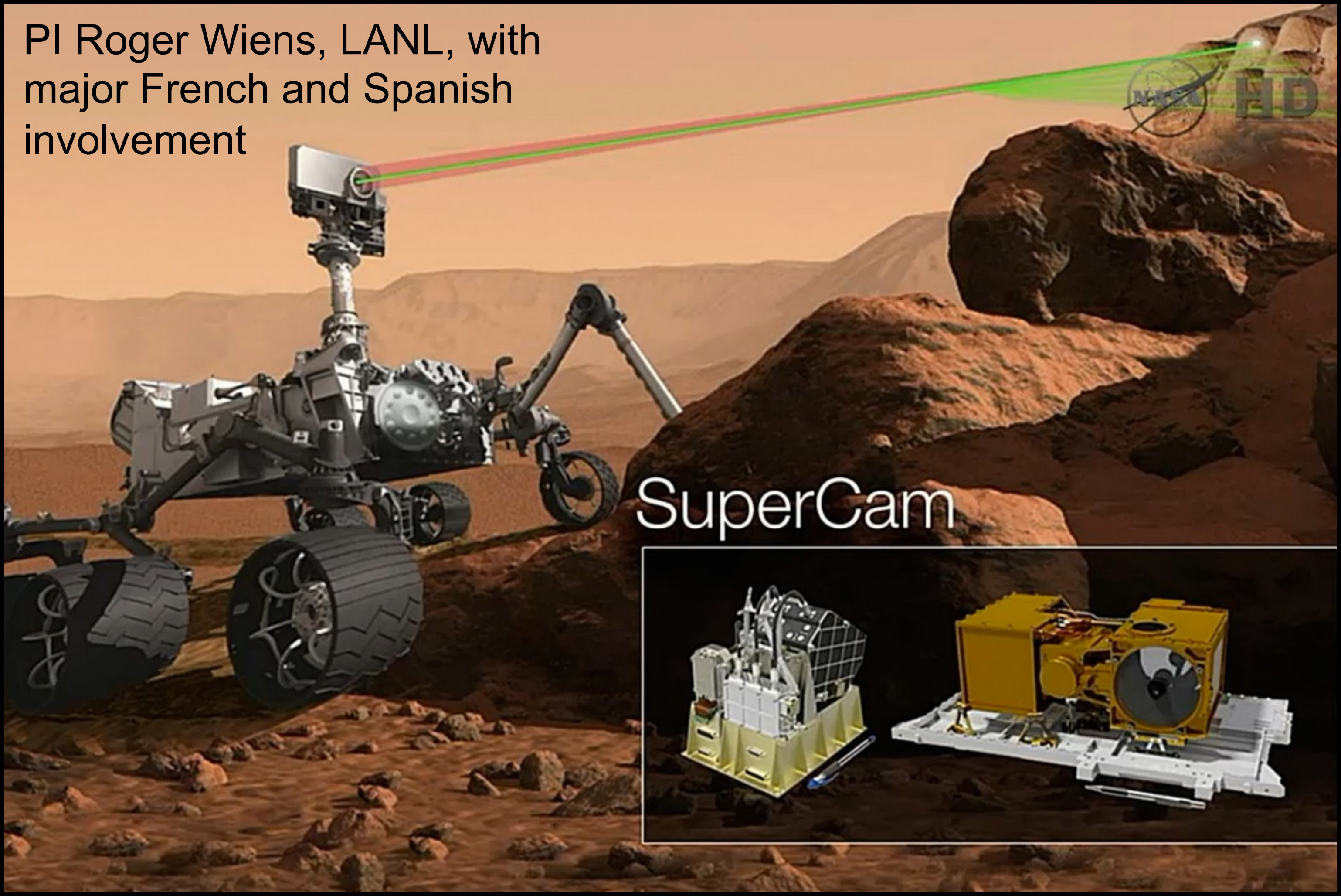


Remote Visual/Textural Imaging

PI Jim Bell, ASU (with Malin Space Science Systems)

-improved stereo zoom camera with strong MSL heritage

Remote Chemistry, Mineralogy, and Imaging



Laser induced breakdown spectroscopy (LIBS) + remote Raman and fluorescence spectroscopy + visible and infrared spectroscopy + remote micro-imaging ("telescope").

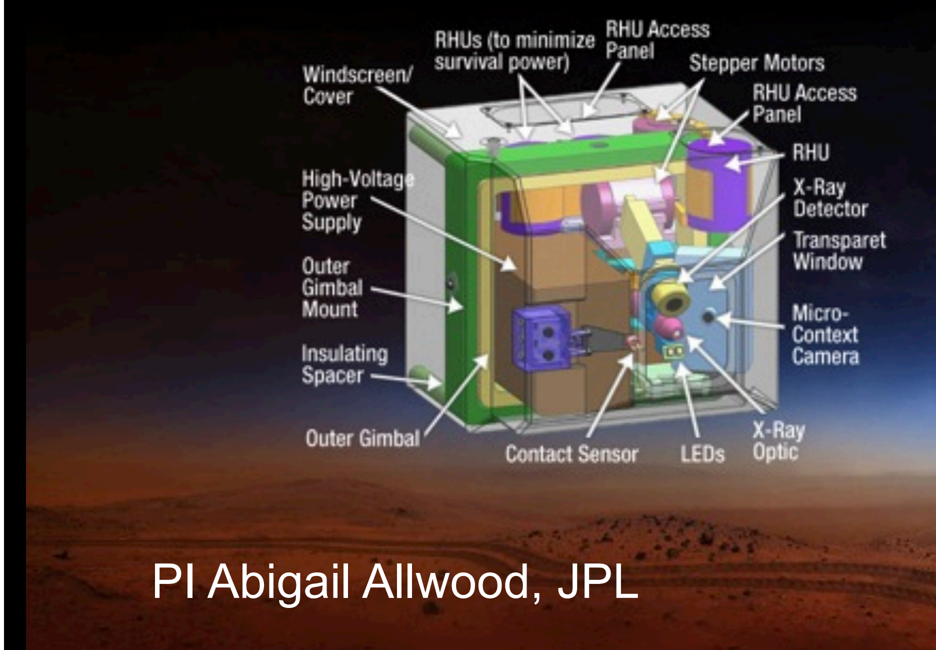
Fine Scale Organic Mapping

PI Luther Beegle, JPL

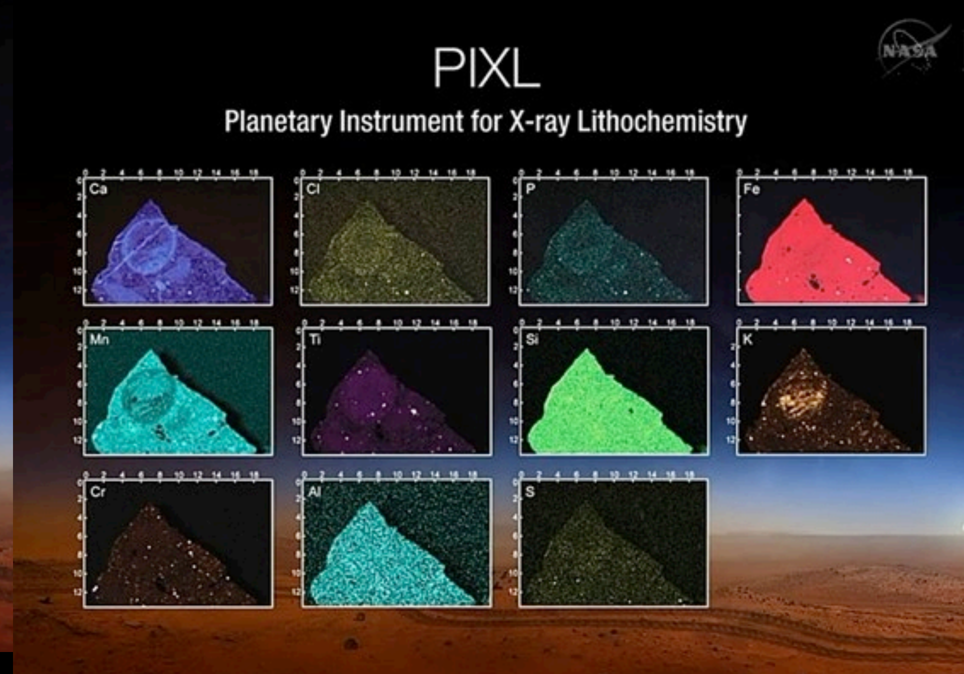
Laser induced fluorescence and Raman spectroscopy to identify organic molecules at the thin-section scale; high spatial resolution (~50 um).

Fine Scale Chemistry

PIXL Arm-Mounted Sensor Head

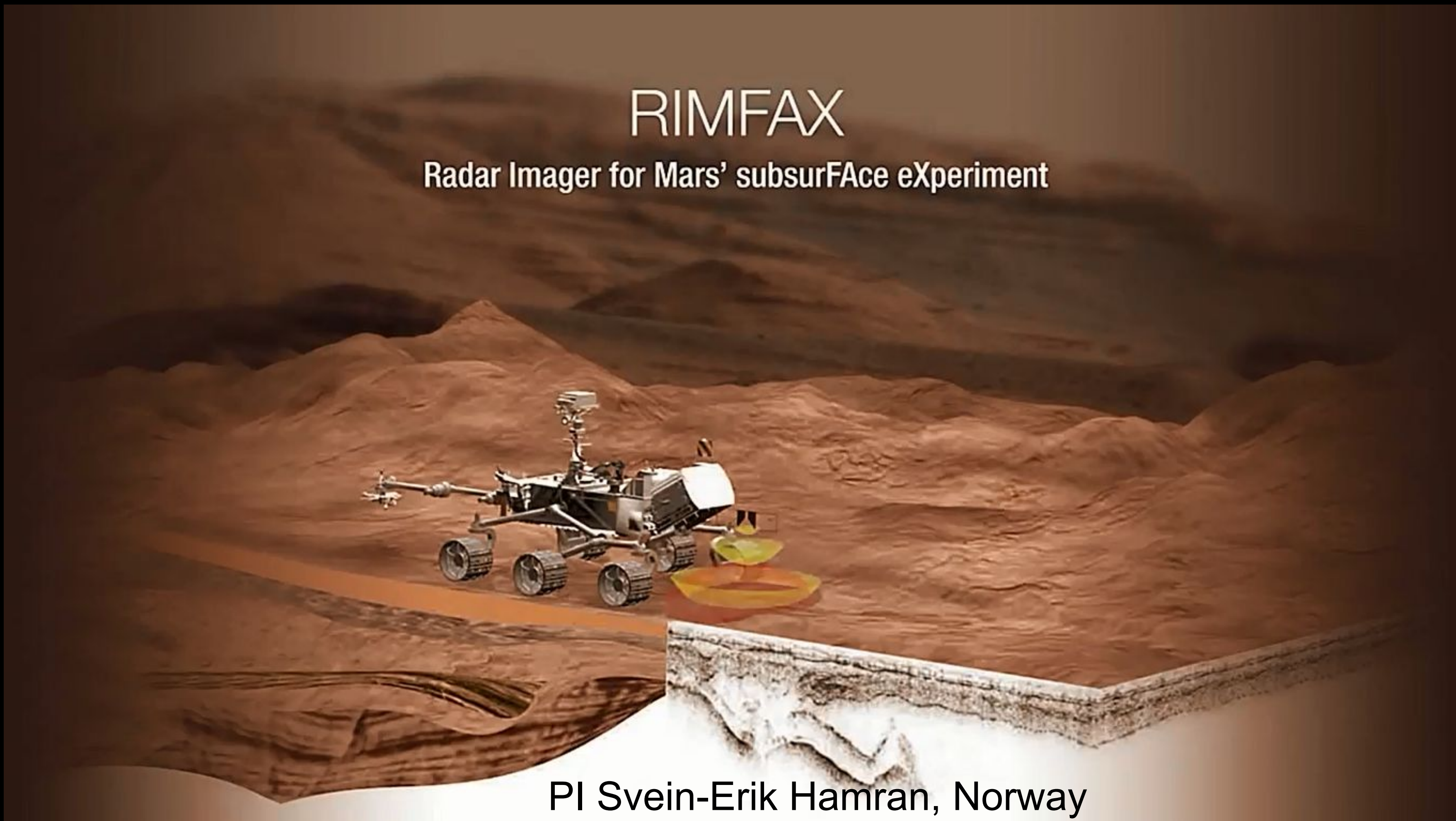


PI Abigail Allwood, JPL



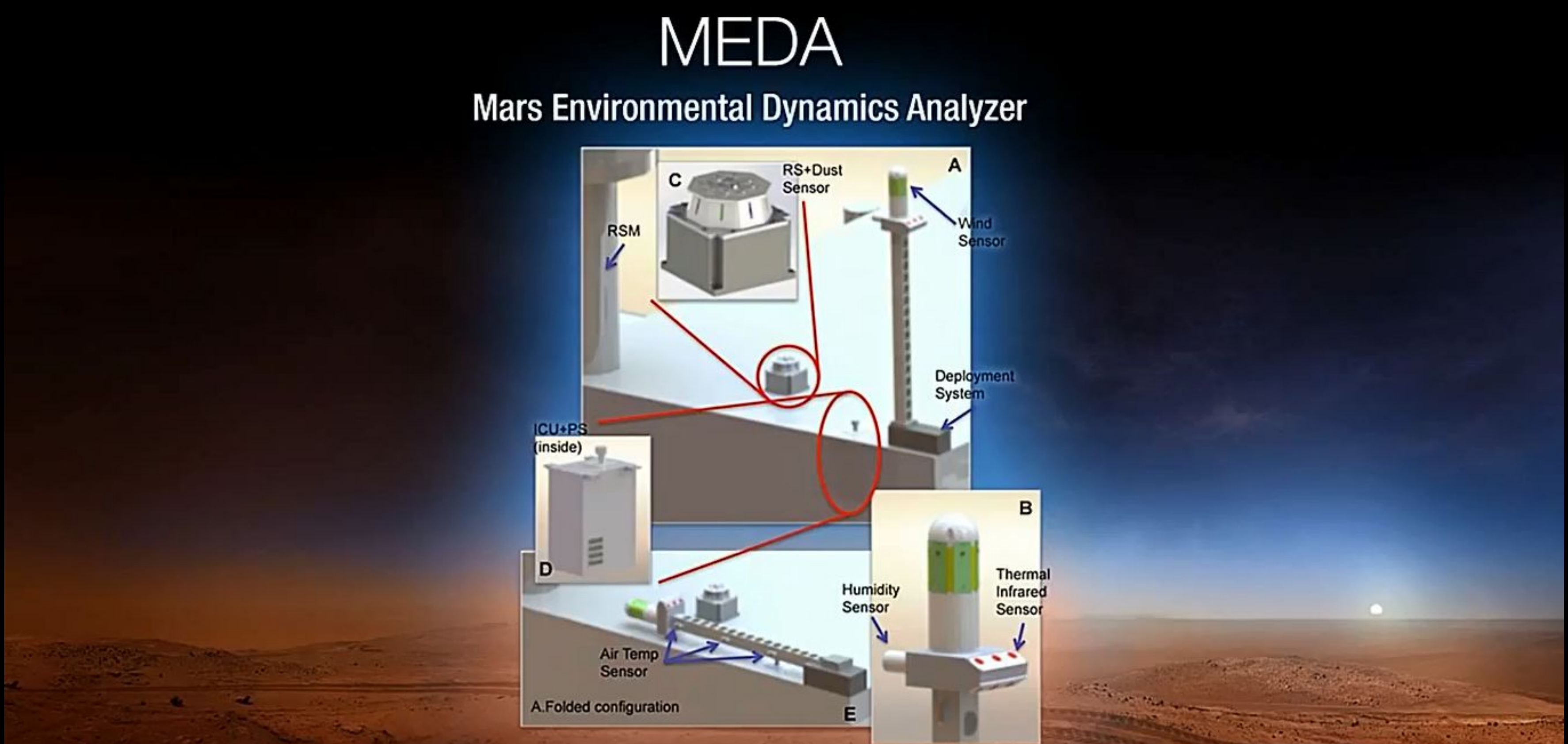
X-ray fluorescence technique to map rock chemical composition (major and minor elements) at the ~50 um scale.

Geologic Characterization



Ground penetrating radar to map sub-surface geologic structure down to 500 m depth

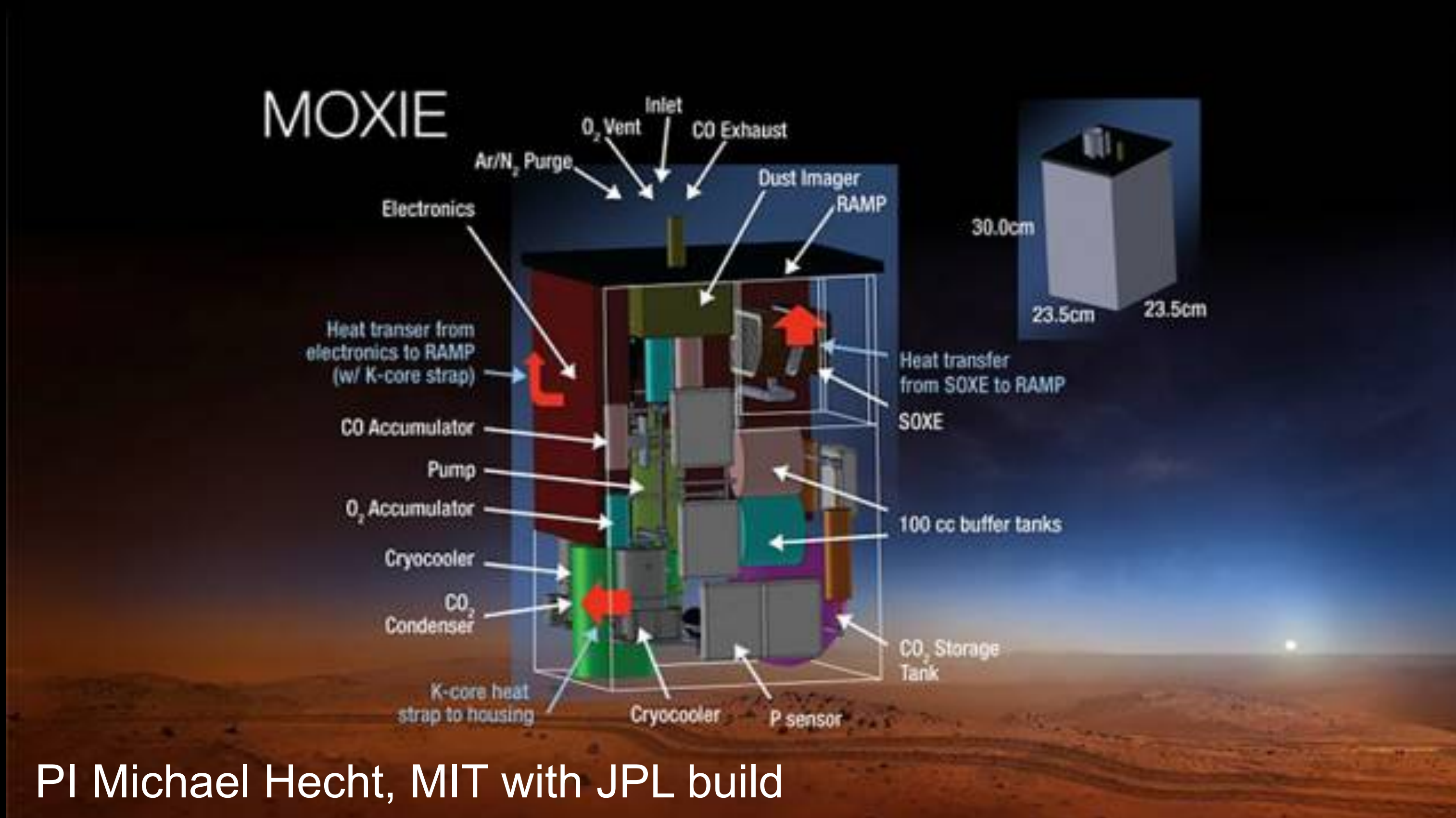
Environmental Monitoring



PI Jose Rodriguez Manfredi, CAB Madrid, Spain

Temperature, humidity, wind, solar radiation, and dust analyzer

In Situ Resource Utilization

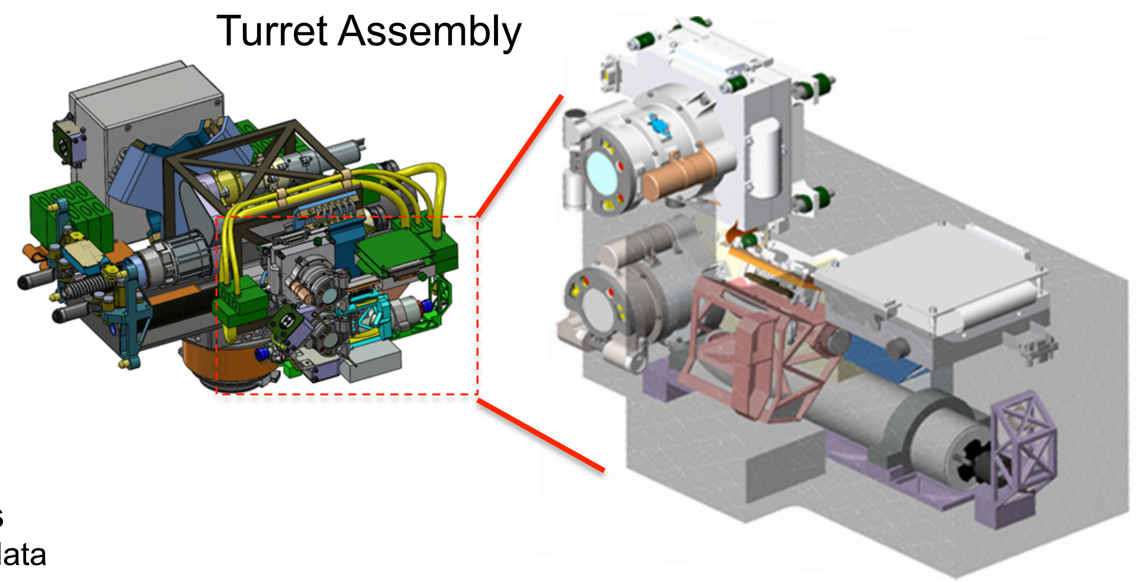


Converts CO_2 to O_2 as possible future resource (oxidant)

Mars 2020 Payload Update

Added Wide Angle Topographic Sensor for Operations and eNgineering (WATSON)

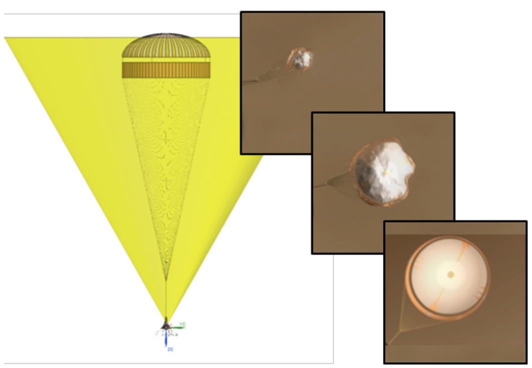
- Augmented turret fine-scale imaging capability by adding MAHLI heritage optic + mux board to SHERLOC instrument
- Provides contextual science and engineering data



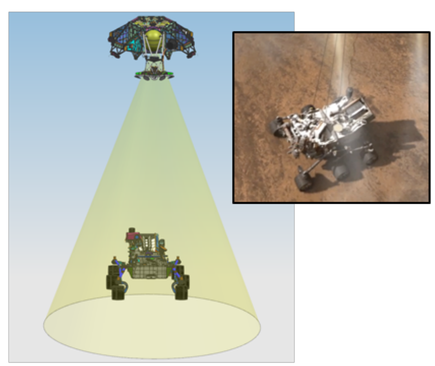
Added EDL / Parachute Uplook Cameras

- Improved EDL instrumentation for engineering data
- Parachute up-look, descent stage down-look, & rover up-look cameras

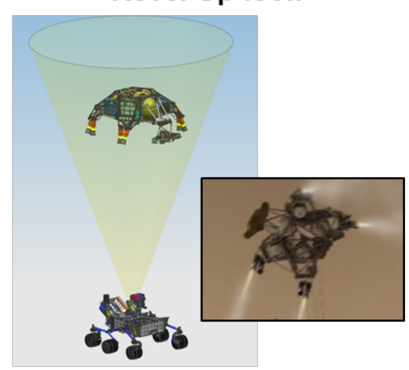
Parachute Up-look



Descent Stage Down-look



Rover Up-look

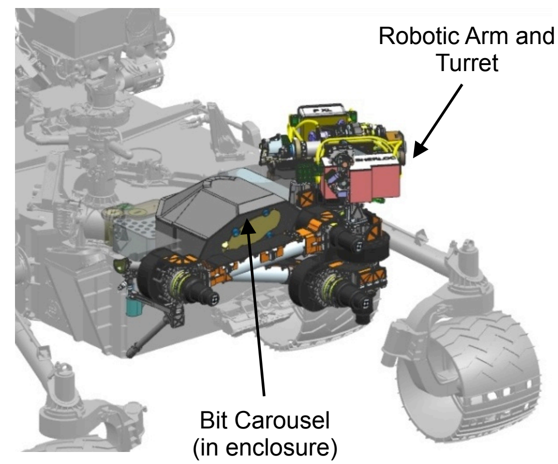


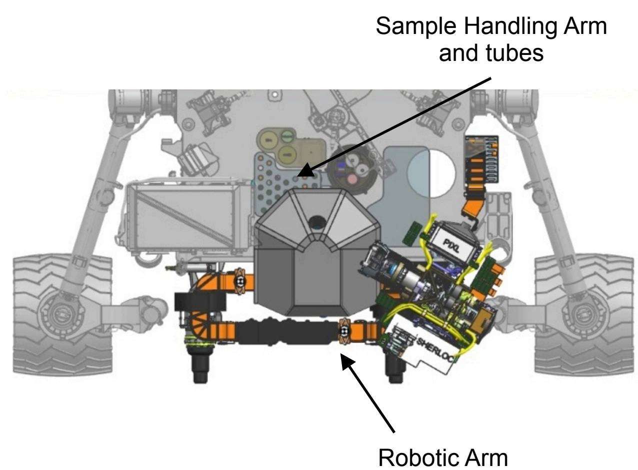
Mars 2020 Sampling and Caching System (SCS)

Scope:
- Acquire and seal samples of Martian surface material
  - Rock Cores
  - Regolith

Approach:
- Use MSL-like robotic arm for sample acquisition
- Rotary Percussive coring drill (MSL-like mechanism) for sampling
- Acquire samples directly into sample tubes
- Process filled sample tubes within controlled volume using a sample handling arm
- Hermetically seal samples in tubes
- Cache samples on Mars for possible future return to Earth

Status:
- Architecting of system is nearing completion
- Design of many elements is underway: Robotic arm; sample handling arm and elements
- Approach to sample tubes disposition: robust approach to minimize risks across program
  - Completed examination of 2 viable approaches: monolithic cache and adaptive cache
  - Investigating "Hybrid" approaches
    - Smaller cache container holding subsets of sample tubes from all regions sampled
    - Operational Hybrid





Planetary Protection Activities

- NASA HQ has established well-defined Level 1 organic and biological cleanliness requirements.
- Project has established and analyzed a Rover / SCS design response to all the Level 1 Planetary Protection / Contamination Control requirements.
- Project presented PP design/approach to the MEP chartered PP Implementation Review on 3/3-3/4 (see board summary)
- On-going Project and PPO interaction to support Categorization Letter and Planetary Protection Plan by PDR (December)

PP Implementation Approach Independent Assessment Review

Review Objectives/Products

- Assess Mars 2020 PP planning, including requirements through execution
- Provide MEP Director feedback on:
  - Requirement interpretation
  - Technical feasibility and efficacy of approach
  - Schedule and cost impact
  - Risk implications for on-time completion
- Determine if NASA team understands task
- Provide recommendations on go-forward plan

Board Members in Attendance
Phil Christiansen (ASU), Chair
Michael Meyer, Exec Secretary
John Rummel (ECU)
Mike Hagopian (SRB)
Andrew Steele (Carnegie)
Judy Allton (JSC)
Ben Clark (SS)

Board Report Highlights

Summary

1. Project taking necessary steps
2. Architecture appears executable and compliant, pending additional work, to PP requirements
3. Level 1 PP requirements are formulated.
4. Project team highly committed to meeting PP requirements with integrated, SE approach.
5. Project architecture based on IVb cleaning for sample intimate hardware, IVa elsewhere.
6. Risk:
   - Ongoing transport analysis
   - Experimental support of analysis
   - Few alternatives

Response

1. Project concurs with the board report.
2. 12 specific findings. Project has accepted all and are working responses and plans.
3. Near-term focus is on sensitivity assessment and verification activities associated with the molecular and particulate transport analysis
4. Project has conducted independent expert reviews of work to-date, and will continue to do so.

Mars 2020 Summary

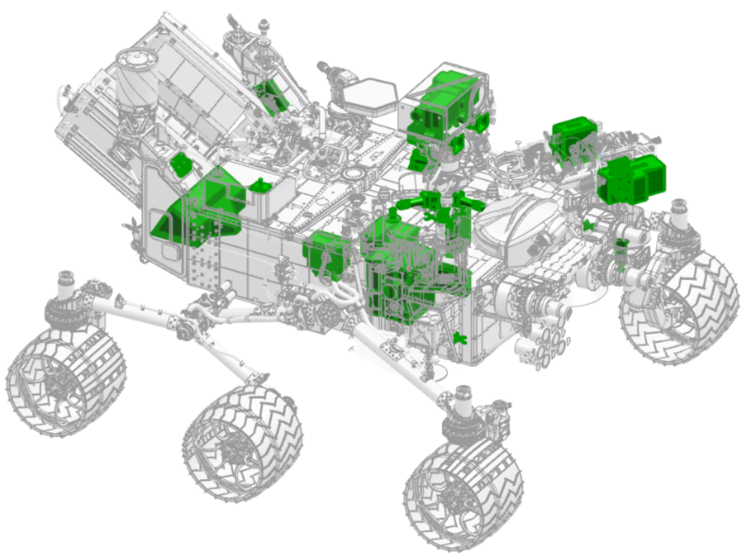
- Completed Phase A and formally entered Phase B of formulation
  - Completed instrument accommodation reviews, including implementing design modifications required at selection
  - SRB reported: *"Project is more mature than most in Phase A, ready for KDP-B decision milestone and Phase B start."*
  - Approved for Phase B by Agency Program Management Council (APMC) on May 20

- High-heritage approach is providing stable foundation for Mars 2020. Heritage hardware (~90% of the flight system by mass) is essentially in Phase C/D. Parts buys and procurements for items with low risk of change are proceeding at a fast pace

- Published environmental impact statement and issued Record of Decision to baseline radioisotope power system, thus completing compliance with National Environmental Policy Act (NEPA)

- Working detailed engineering and design trades for cache system implementation

- Rover systems / Payload Update:
  - Agreement reached with Spain to provide high gain antenna
  - Upgraded engineering camera design with color and improved resolution compared to MSL navcam/hazcams
  - Added EDL / Parachute Uplook Cameras
  - Augmented SHERLOC with infinite focus fine-scale color imager (based on MSL MAHLI)
  - RIMFAX formally selected for flight based on accommodation



- Continuing to evaluate Terrain Relative Navigation (TRN) capability for potential inclusion on the mission

- Second landing site workshop planned, August 2015

Project has made excellent progress to date, with plenty of challenging work still ahead